REMARKS

The specification has been revised to correct a reference symbol error and a spelling error, and to delete an inappropriate splitting of a term. On page 27, paragraph 87, "Getter coatings 74" has been corrected to "Coatings 74" because coatings 74 as described in paragraph 87 need not perform a gettering function. The status of the additional patent applications cited on pages 56 and 58 of the specification has been updated.

The portion of the Periodic Table containing boron, aluminum, gallium, indium, and thallium is referred to (a) as Group "IIIB" according to the previous IUPAC convention, (b) as Group "IIIA" according to the CAS convention, and (c) as Group 13 according to the current IUPAC convention. Inasmuch as the elements that form Group "IIIB" in the previous IUPAC convention form Group "IIIA" in the CAS convention, a parenthetical "13" has been inserted after "IIIB" in each of the recitations on pages 6 and 25 of the specification that boron, aluminum, gallium, indium, and thallium fall into Group "IIIB" of the Periodic Table. With the same revisions being made in the claims, these changes to the specification clarify what is meant by Group "IIIB" in the claims.

Claims 6, 7, 9, 16, 58, 67, and 70 have been amended. No claims have been added or canceled. Accordingly, Claims 1 - 96 are still pending.

The term "Group IIIB" has been changed to "Group IIIB (13)" in Claims 6, 9, and 67 to clarify what is meant by "Group IIIB" in these three claims in accordance with what is mentioned above. The revisions to Claims 7, 16, 58, and 70 correct several errors in claim dependency and grammar.

LAW OFFICES OF
SKJERVEN MORRILL
MacPHERSON LLP

25 METRO DRIVE
SUITE 700
SAN JOSE, CA 95110
(408) 453-9200
FAX (408) 453-7979

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Please telephone applicants' attorney at 408-453-9200, ext. 1371, if there are any questions.

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Respectfully submitted,

Ronald J. Meetin

Ronald J. Meetin
Attorney for Applicants
Reg. No. 29,089

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LAW OFFICES OF
SKJERVEN MORRILL
MacPHERSON LLP

25 METRO DRIVE
SUITE 700
SAN JOSE, CA 95110
(408) 453-9200
FAX (408) 453-7979

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[0006] The electrons emitted by regions 26 pass through light-reflective layer 38 before striking light-emissive regions 34. In so doing, the electrons lose some energy. The image intensity increase resulting from the light-reflective nature of layer 38 at least partially compensates for any image intensity decrease caused by this electron energy loss. Nonetheless, it would be desirable to further improve the image intensity in a light-emitting device whose anode overlies the device's light-emitting regions.

[0007] Each light-emitting region in a light-emitting device such as that of Fig. 1 normally consists of light-emissive particles formed with phosphor material. The constituents of the phosphor particles commonly include elements such as sulfur or/and oxygen. When the light-emissive particles are struck by electrons, some of the sulfur or/and oxygen is commonly released in gaseous form into the interior of the display. The so-released gases can contaminate the display and cause it to degrade.

[0008] Petersen et al ("Peterson"), U.S. Patent 5,844,361, addresses the problem of outgassing from phosphor particles in a light-emitting device of a flat-panel CRT display by chemically treating the outer particle surfaces in a way intended to reduce undesired outgassing. Figs. 2 and 3 depict two examples of Petersen's approach in which light-emissive regions overlie transparent substrate 40. Each light-emissive region consists of a layer of phosphor particles 42.

[0009] One coating 44 fully surrounds each phosphor particle 42 in the example of Fig. 2. Coatings 44 can alter the surface chemistry of particles 42 in such a way that they are more thermodynamically resistant to outgassing. Alternatively, coatings 44 can simply be impervious encapsulants that substantially prevent any contaminant gases produced by

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plate and passes through it. Part of the emitted light travels generally backward, likewise including partially sideways, away from the plate.

[0016] In a first aspect of the invention, each light-emissive particle is covered with a light-reflective coating positioned in the manner indicated above to conformally cover part of the particle's outer surface. As a result, the particle coatings reflect forward some of the initially rear-directed light emitted by the particles. While the light-reflective layer normally situated over the particles above the light-reflective coatings performs generally the same function as the light-reflective particles, the combination of the light-reflective coatings and the light-reflective layer causes more light to be directed forward than would be achieved solely with the light-reflective layer. Hence, usage of the light-reflective coatings enables the light intensity to be increased in the forward direction.

[0017] The coatings are typically made light reflective by forming them from one or more of the metals beryllium, boron, magnesium, aluminum, chromium, manganese, iron, cobalt, nickel, copper, gallium, molybdenum, palladium, silver, indium, platinum, thallium, and lead, including alloys of one or more of these metals. Boron, aluminum, gallium, indium, and thallium, all of which fall into Group IIIB (13) of the Periodic Table, are attractive for the light-reflective coatings because none of these five metals is an electron donor. Silver and copper are attractive because they are substitutional species in metal sulfide phosphors suitable for implementing the light-emissive particles to respectively emit blue and green light.

[0018] In a second aspect of the invention, each light-emissive particle is partially covered in the preceding manner with a getter coating for sorbing (adsorbing or absorbing) contaminant

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particles 72. Because coatings 74 are in front of layer 70, much of the initially rear-directed light emitted by particles 72 is reflected forward by coatings 74 and thus does not reach layer 70. However, some of the phosphor-emitted light passes by or through coatings 74 and impinges on layer 70 directly or after one or more intermediate reflections. Layer 70 then reflects that light forward so that part of it passes through faceplate 64. Accordingly, layer 70 increases the light intensity in the forward direction so as to further increase the image intensity. The combination of layer 70 and coatings 74 provides more increase in the forward light intensity than would occur solely with coatings 74 or solely with layer 70.

[0081] Light-reflective coatings 74 normally consist of metal. Candidate metals for coatings 74 are beryllium, boron, magnesium, aluminum, chromium, manganese, iron, cobalt, nickel, copper, gallium, molybdenum, palladium, silver, indium, platinum, thallium, and lead. Coatings 74 may contain two or more of these metals or may consist of an alloy of one or more of these metals with one or more other materials. Boron, aluminum, gallium, indium, and thallium, which all fall into Group IIIB (73) of the Periodic Table, are attractive for coatings 74 because none of these five metals is an electron donor. Consequently, each of them is highly unlikely to cause phosphor particles 72 to emit light of the wrong color should atoms of any of these five metals migrate into particles 72.

[0082] The choice of metals or other materials to implement light-reflective coatings 74 typically depends on the constituency of phosphor particles 72 and thus on the type of light emitted by particles 72. Specifically, coatings 74 which (partially) cover particles 72 that emit light of one type may consist of different material than coatings 74 which (partially) cover particles 72 that emit light of another type.

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[0085] Phosphor particles 72 may produce contaminant gases when struck by high-energy charged particles, especially electrons emitted by electron-emissive regions 58. For example, particles 72 may outgas sulfur when part or all of them are metal sulfide phosphors, or oxygen when part or all of them are metal oxide phosphors. When part or all of particles 72 are metal oxysulfide phosphors, they may outgas both sulfur and oxygen. Outgassed sulfur can be in the form of atomic/molecular sulfur or/and in the form of sulfur-containing compounds. Sulfur, although a solid at standard temperature (0°C) and pressure (1 atm.), is gaseous at the high vacuum, typically a pressure of 10^{-6} torr or less, present in the interior of the display of Fig. 4 and 5. Unless these contaminant gases are prevented from leaving the immediate vicinity of particles 72, the contaminant gases can enter the interior of the display and cause damage.

[0086] As discussed further below, light-reflective coatings 74 provide protective shields that reduce the severity of certain damaging effects, such as outgassing and erosion, that occur to phosphor particles 72 when they are struck by high-energy electrons or/and other high-energy charged particles. These advantages can be partially or largely fully achieved even through coatings 74 may be so thin as to not provide adequate light reflection. Additional reliance is then placed on light-reflective layer 70 for reflecting the phosphor-emitted, rear-directed light forward.

[0087] ~~Getter coatings~~ Coatings 74 may, in accordance with the invention, consist of one or more of the following metals provided over particles 72 to a thickness below that needed for adequate light reflection: beryllium, boron, magnesium, aluminum, titanium, vanadium, chromium, manganese, iron, cobalt, nickel, copper, gallium, zirconium, niobium, molybdenum, palladium, silver, indium, barium, tantalum, tungsten, platinum, thallium, lead, and thorium, including alloys of one or more of these twenty-six

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metals. Alternatively or additionally, coatings 74 may consist of oxide one or more of magnesium, chromium, manganese, cobalt, nickel, and lead. When coatings 74 are implemented with one or more of these six metal oxides, coatings 74 normally provide the protective shielding function even though they may not furnish adequate light reflection.

[0088] Light-reflective coatings 74 function as getter coatings when they consist of certain of the preceding thirty-two metals and metal oxides. Getter candidates for this purpose include the metals magnesium, titanium, vanadium, chromium, manganese, iron, cobalt, nickel, copper, zirconium, niobium, molybdenum, palladium, silver, barium, tantalum, tungsten, platinum, lead, and thorium, including alloys of one or more of these metals. Coatings 74 can then sorb contaminant gases, including gases released by phosphor particles 72 upon being struck by electrons as well as gases otherwise present in the interior of the flat-panel display. Magnesium, chromium, manganese, iron, cobalt, nickel, copper, molybdenum, palladium, silver, platinum, and lead, are particularly suitable for sorbing sulfur, especially sulfur released by particles 72 when they are metal sulfide phosphors (again including metal oxysulfide phosphors). In one embodiment, coatings 74 consist largely of palladium or/and chromium.

[0089] Alternatively or additionally, coatings 74 can be implemented with oxide of one or more of magnesium, chromium, manganese, cobalt, nickel, and lead to provide a gettering function. Each of these six metal oxides is particularly suitable for sorbing sulfur. Coatings 74 consist largely of magnesium oxide in one embodiment.

[0090] When coatings 74 contain two or more of preceding twenty-six metals and metal oxides for sorbing contaminant gases, the two or more getter materials are normally mixed together to form

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[0158] An optional protective (or isolation) layer 90 is situated on black matrix 68 and extends substantially all the way down its sidewalls. The combination of faceplate 64 and protective layer 90 encapsulates matrix 68. When electrons emitted by regions 58 strike light-emitting device 80, the polymeric material which typically forms upper layer 88 of matrix 68 can emit contaminant gases. Protective layer 90 slows the entry of these gases into the interior of the display. Further details on protective layers such as layer 90 are presented in Haven et al, U.S. patent application 09/087,785, filed 29 May 1998, now U.S. Patent 6,215,246 and in Curtin et al, U.S. patent application 09/698,696, filed 27 October 2000.

[0159] Fig. 8 illustrates an example in which protective layer 90 extends over faceplate 64 at the bottoms of the black-matrix openings that contain light-emissive regions 66. Layer 90 then consists of material transmissive of visible light. This material is typically an electrical insulator such as silicon oxide, silicon nitride, or/and aluminum oxide. Alternatively, layer 90 can block, i.e., absorb or/and reflect, visible light. In that case, portions of layer 90 are removed at the bottoms of the black-matrix openings.

[0160] Pieces 92 of the material that forms first intensity-enhancement coatings 82 are depicted as being situated on protective layer 90 at the bottoms of the black-matrix openings at locations below the spaces between phosphor particles 72 of each light-emissive region 66 in the example of Fig. 8. Pieces 94 of the material that forms second intensity-enhancement coatings 84 are similarly illustrated as being situated on pieces 92. Depending on how coatings 82 and 84 are created, pieces 92 of the first intensity-enhancement material and/or pieces 94 of the second intensity-enhancement material may not be present in light-emitting device 80.

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[0164] In conjunction with having reduced chemical reactivity compared to the native aluminum oxide layer, layer 102 has a lower gas-sticking coefficient than the native oxide layer. Consequently, the likelihood of contaminant gases adhering to the interior surface of the active portion of light-emitting device 80 is reduced compared to what would occur if the interior surface of the active portion were formed with the native aluminum oxide layer. Further details on layers such as additional layer 102 are presented in Cummings et al, co-filed U.S. patent application 09/823,872, attorney docket No. CT-F137 US.

[0165] Light-emitting device 80 in the implementation of Fig. 8 normally also includes a thin peripheral electrode (not shown) situated outside the active portion of device 80. The peripheral electrode consists of electrically non-insulating material, specifically electrically conductive material such as aluminum or an aluminum alloy. The peripheral electrode contacts both light-reflective layer 70 and charge-removal layer 96 so as to provide them with the display's anode potential and to provide access to layers 70 and 96 for removing charge.

[0166] The implementation of Fig. 8 can be modified to have more than two intensity-enhancement coatings situated above part of the outer surface of each phosphor particle 72 in the manner described above in connection with Fig. 7.

[0167] Figs. 9a - 9e (collectively "Fig. 9") illustrate a general process for manufacturing light-emissive device 80 of Fig. 7 in accordance with the invention starting from the stage of Fig. 6b in the process of Fig. 6. See Fig. 9a which repeats Fig. 6b. Phosphor particles 72 are introduced into the openings in black matrix 68 to form light-emissive regions 66 as shown in Fig. 9b. The introduction of particles 72 into the black matrix openings is performed in the same way as in the process of Fig.

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[0238] Intensity-enhancement coatings 112 have the same characteristics, including light-refractive properties here as in light-emitting device 80 of Fig. 7. Since one or more parts of the outer surface of each coating 112 are normally subjected to the high vacuum in the display's interior, each phosphor particle 72 and overlying coating 112 normally form a structure in which the average refractive index progressively decreases in going from that particle 72 through overlying coating 112 to the high vacuum along at least part of that coating 112.

[0239] Similar to what occurs in light-emitting device 110 of Fig. 11, more rear-directed light emitted by phosphor particles 72 in light-emitting device 130 normally escapes particles 72 and intensity-enhancement coatings 112 traveling backward, including partially sideways, at locations spaced apart from where coatings 112 come closest to light-reflective layer 70 than, in the absence of coatings 112 (but with light-reflective coatings 74 still present and thereby lying directly on particles 72) would escape particles 72 moving backward, again including partially sideways, at locations spaced apart from where particles 72 would then come closest to layer 70. Part of the increased amount of phosphor-emitted rear-directed light escaping particles 72 and coatings 112 impinges on layer 70 in such a way as to be reflected forward to the side of particles 72. The forward light intensity can thus be enhanced.

[0240] Part of the phosphor-emitted rear-directed light passes ~~though~~ through intensity-enhancement coatings 112, is reflected off light-reflective coatings 74, passes through phosphor particles 72, and then passes through faceplate 64. This can further increases the light intensity in the forward direction. Coatings 74 and 112 can thereby produce an increase in the display's image intensity. Accordingly, the combination of coatings 74 and 112 and layer 70 can provide greater forward

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light intensity and image intensity than would occur solely with layer 70 or solely with coatings 74 and 112.

[0241] As in light-emitting device 52, light-reflective coatings 74 function as getters when they consist of one or more of the metals magnesium, titanium, vanadium, chromium, manganese, iron, cobalt, nickel, copper, zirconium, niobium, molybdenum, palladium, silver, barium, tantalum, tungsten, platinum, lead, and thorium, or an alloy of one or more of these metals. Likewise, coatings 74 in light-emitting device 130 may alternatively or additionally be formed with oxide of one or more of the metals magnesium, chromium, manganese, cobalt, nickel, and lead. Coatings 74 can then sorb contaminant gases, especially sulfur-containing gases, released by phosphor particles 72 before those gases escape the immediate vicinity of particles 72 and cause damage elsewhere. Since light-reflective layer 70 is perforated, coatings 74 can also sorb contaminant gases that originate in the display's interior and pass through layer 70. In one embodiment of device 130, coatings 74 consist substantially of palladium or/and chromium.

[0242] Light-emitting device 130 can be modified in various ways. Each intensity-enhancement coatings 112 can be replaced with two or more intensity-enhancement coatings of progressively decreasing average refractive index in moving away from underlying phosphor particle 72. In general, part of the outer surface of each particle 72 can be covered with m intensity-enhancement coatings having the properties, including progressively decreasing average refractive index, described above for the modifications of light-emitting devices 80 and 110. Light-reflective coatings 74 are situated on the mth intensity-enhancement coatings.

[0243] Fig. 18 depicts a side cross section of part of the active portion of an implementation of light-emitting device 130

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CLAIMS 6, 7, 9, 16, 58, 67, AND 70 WITH ANNOTATIONS TO INDICATE REVISIONS, OF U.S. PATENT APPLICATION 09/823,815

6. (Amended) A structure as in Claim 3 wherein the metal of the light-reflective coatings comprises at least one Group IIIB (13) metal.

7. (Amended) A structure as in Claim 1 [7] further including an electron-emitting device comprising an electron-emissive region for emitting electrons which pass through the light-reflective coatings and cause the light-emissive particles to emit light.

9. (Amended) A structure comprising:

a plate;

a light-emissive region overlying light-transmissive material of the plate and comprising a plurality of light-emissive particles each having an outer surface; and

a group of coatings comprising at least one Group IIIB (13) metal, each coating generally conformally overlying part of the outer surface of a corresponding different one of the light-emissive particles so as to be spaced apart from where that light-emissive particle is closest to the plate.

16. (Amended) A structure as in Claim 15 [13] wherein the light-emissive particles comprise metal sulfide phosphors with copper substitution.

58. (Amended) A structure as in Claim 57 wherein the contrast-enhancement coatings appear largely black as [and]

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seen through the plate from opposite the light-emissive region.

67. (Amended) A method comprising:

providing a plurality of light-emissive particles over light-transmissive material of a plate to form a light-emissive region; and

subsequently providing at least one Group IIIB (13) metal over the light-emissive particles to form a group of coatings such that each coating generally conformally overlies part of the outer surface of a corresponding different one of the light-emissive particles and is spaced apart from where that light-emissive particle is closest to the plate.

70. (Amended) A method as in Claim 69 wherein the getter coatings are light reflective [light-reflective].

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